U. S. ARMY
TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

TRECOM TECHNICAL REPORT 64-36

ENGINEERING SURVEY OF AIRCRAFT STRUCTURAL FAILURES CAUSED BY CORROSION, FATIGUE, AND ABRASION

FINAL REPORT

Task 1D121401A14203
Contract DA 44-177-AMC-98(T)

July 1964

prepared by:

UNIVERSITY OF OKLAHOMA RESEARCH INSTITUTE
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HEADQUARTERS
U S ARMY TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

This engineering survey was carried out under Contract DA 44-177-AMC-98(T) by the University of Oklahoma Research Institute under the direction of Dr. Gene M. Nordby. The survey was made of aircraft structural failures caused by corrosion, fatigue, and abrasion.

The report has been reviewed by the U. S. Army Transportation Research Command and is considered to be technically sound.

The conclusions made by the contractor are considered by this command to be valid.

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Prepared by
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Norman, Oklahoma

for
U.S. ARMY TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

PREFACE

This report covers an engineering survey of aircraft structural failures caused by corrosion, fatigue, and abrasion. The work was accomplished as a research program in the field of structural composites and advanced aircraft materials under U.S. Army Transportation Research Command (USATRECOM) Contract DA 44-177-AMC-98(T). TRECOM Technical Report 64-37 pertains to research conducted under the same contract in the field of fiberglass reinforced sandwich structure for airframe use and is reported separately.

The contract period was from June 10, 1963, to January 31, 1964.

The work was directed by Dr. Gene M. Nordby, Dean of the College of Engineering at the University of Oklahoma. Mr. Bruce V. Ketcham, Professor of Aerospace and Mechanical Engineering, and Mr. W. C. Crisman, Research Engineer, were the principal engineers.

The University of Oklahoma Research Institute expresses appreciation for the assistance by the U.S. Army Aviation Materiel Command, St. Louis, Missouri, in making available their failure report files.

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SUMMARY

A survey of Army aircraft structural failures caused by corrosion, fatigue, and abrasion was made to define critical areas of future structural research. The primary source of data was the Army failure reports, "Equipment Improvement Recommendation". Because of the great number of reports available, a sampling was made consisting of basic airframe failures on four helicopters and two fixed-wing aircraft for the period 1 January 1963 to 31 August 1963. The reports were analyzed individually, and the data were consolidated. Analysis of all data revealed four significant problem areas: (1) corrosion and fatigue of primary airframe structure; (2) separation of metal bonded joints on rotor blades; (3) erosion of rotor blade leading edges; and (4) sustaining rotor blade balance.

CONCLUSIONS

On the basis of the analysis of recent failure reports, it is concluded that:

1. Other promising structural materials should be developed since current research on metallic structural materials in use does not point to correction of the problems of fatigue and corrosion revealed by the analysis. The largest association of failures pertaining to primary aircraft framework (39 per cent of all failures) was found in the area of fatigue and corrosion.

2. Although rotor blade metal bonding separation represents only 9 per cent of the failure sampling, it is an area for concern because it directly involves the integrity of the airframe.

3. Rotor blade damage, especially leading edge erosion, is a problem which should be further investigated.

4. Rotor blades constructed with perforated honeycomb core materials are subject to balance changes due to water collection within the blade.

RECOMMENDATIONS

It is recommended that:

1. Research work in the field of fiberglass-reinforced plastic material for use in primary airframe structures be pursued vigorously.

2. Further study be conducted on the rotor blade bonding separation problem.

3. The solution to the problem of rotor blade damage in operation -- in particular, leading edge erosion -- be sought not only by continued search for protective materials but by the development of new materials of construction.

4. When honeycomb core material is used in rotor blade construction, the nonperforated or sealed type be favored.

DISCUSSION

INTRODUCTION

As a part of an advanced materials research program sponsored by the U.S. Army Transportation Research Command (USATRECOM) under Contract DA 44-177-AMC-98(T), the University of Oklahoma Research Institute conducted a survey of Army aircraft structural failures caused by corrosion, fatigue, and abrasion. The purpose of the survey was to define critical areas of future structural research.

A full-depth survey could not be made because no one document that could be obtained and examined during the desired 6-month contract period contained enough information. A review of Army aircraft failure documents and their availability dictated the use of the "Equipment Improvement Recommendation" (EIR) reports as the best available source of failure data, but even these were not sufficiently complete. Therefore, the limitations described below were imposed on the findings of this survey.

In most cases the EIR reports gave no background data on the failures, nor could the contractor obtain drawings or operating manual details on the failed element in time to provide adequate assistance. In addition, the possibility for the overlooking and nonreporting of many failures vital to this type of survey exists simply because field personnel may not be fully aware of the importance of certain failures that do not appear to endanger the integrity of the aircraft immediately.

Owing to the limited time of the contract period and the vast number of EIR reports, only a cross section of the reports could be appropriately evaluated. Consequently, the information found in this report represents only a beginning. The cross section chosen was a group of reports (dated between January 1, 1963, and August 31, 1963) on four helicopters (UH-1, OH-13, UH-19, and CH-34) and two fixed-wing aircraft (U-6 and O-1). Pertinent information concerning the basic airframe and rotor blades was included.

DESCRIPTION OF WORK

Initially the work program involved locating the best source of failure reports (EIR's) and establishment of contacts, clearances, and procedures

for report collection. Trips were made to SMC Logistic Data Center, Lexington Army Depot, Lexington, Kentucky, and the U.S. Army Aviation and Materiel Command, St. Louis, Missouri. The most logical source of failure reports and the only one that could be effectively utilized during the contract period was found to be at the latter location.

After screening the repository at the U.S. Army Aviation Materiel Command, some 2,300 reports relevant to structural failures were selected and subsequently read in detail at the University of Oklahoma Research Institute facilities.

The reading yielded 463 valuable failure reports all of which were studied and analyzed in detail. The aspects of the failure important to revealing the underlying cause and to providing guidance for correction were recorded by means of a code (the report analysis system is given in the appendix). The coded data were then summed both singly and associatively in an effort to determine problem areas common to all the aircraft -- patterns of failure, aircraft features with high failure rates, materials with high failure rates, etc. Though the sorting of these data was done by hand, the system was designed so that it could handle a much larger volume via a punch card system.

Finally, the 1963 Defense Documentation Center (DDC) indexes were scanned to get a picture of current work that might have application to the problem areas.

SURVEY RESULTS

Tables 1 through 4 contain the summation from all reports of each item in the breakdown of reported information (each item in the analysis code). These tables served as a guide for obtaining (by further sorting) the significant results listed below. It is emphasized that these results are from an overall point of view and not necessarily from the details of any one aircraft or part -- the failure report information was searched for aspects that could affect or have application to all future aircraft structures.

1. There were several types of failures that could be involved in the fatigue mechanism: Fuselage skin wrinkling accounted for 7 per cent of all failures; metallic cracks accounted for 47 per cent (56 per cent of these were in the primary framework, i.e., skin, stringer, frame, etc.); loose rivets accounted for 1 per cent; and catastrophic fractures on landing gears accounted for

TABLE 1
SUMMATION OF FAILURE OCCURRENCE BY AIRCRAFT IDENTIFICATION CODE

Coded Item*	Elements of the Code*															
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
d.	48	415	0	0	0	0	0	-	-	-	-	-	-	-	-	-
e.	360	65	33	0	2	3	-	-	-	-	-	-	-	-	-	-
	205	0	0	0	42	26	0	0	142	0	0	0	0	28	0	20
	32	147	110	104	17	0	0	0	27	0	7	19	-	-	-	-
f.	463	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-

*Refer to code in appendix.

TABLE 2
SUMMATION OF FAILURE OCCURRENCE BY AIRCRAFT HISTORY CODE

Coded Item*	Elements of the Code*											
	01	02	03	04	05	06	07	08	09	10	11	12
a.	463	0	0	0	0	0	0	-	-	-	-	-
b.	20	14	15	4	1	406	2	1	-	-	-	-
c.	58	326	39	6	1	2	0	1	30	-	-	-
d.	348	92	0	0	1	2	0	19	0	1	0	-
e.	335	103	0	5	1	1	0	18	0	0	0	-
f.	367	1	40	0	0	5	0	33	17	-	-	-
g.	369	1	41	0	0	5	0	32	4	11	-	-
h.	203	2	0	7	0	2	66	102	21	57	2	1
i.	192	2	0	7	0	2	71	106	21	58	2	2
j.	312	0	0	0	0	151	0	-	-	-	-	-
k.	1	461	0	1	0	0	-	-	-	-	-	-
l.	166	91	117	63	18	7	1	-	-	-	-	-
	223	238	2	0	0	0	0	-	-	-	-	-
	142	9	202	86	17	6	1	-	-	-	-	-
m.	147	243	2	36	1	30	1	3	0	0	-	-

*Refer to code in appendix.

TABLE 3
SUMMATION OF FAILURE OCCURRENCE
BY LOCATION OF FAILED PART CODE

Coded Item*	Elements of the Code*																	
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
a.	161	15	1	0	7	42	161	2	36	16	3	0	19	0	0	-	-	-
b.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c.	374	16	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
d.	78	4	16	1	0	40	0	0	8	3	0	53	1	0	2	104	2	11
e.	10	14	46	60	17	33	124	1	0	0	0	0	0	4	2	1	63	52

	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
a.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
b.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
d.	1	26	2	18	8	4	25	0	13	2	15	0	1	2	10	6	4	3
e.	25	7	2	2	0	0	-	-	-	-	-	-	-	-	-	-	-	-

*Refer to code in appendix.

TABLE 4
SUMMATION OF FAILURE OCCURRENCE BY
MATERIAL AND FAILURE DESCRIPTION CODE

Coded Item*	Elements of the Code*													
	01	02	03	04	05	06	07	08	09	10	11	12	13	14
a.	110	211	109	0	0	2	10	0	3	8	10	-	-	-
b.	0	445	0	0	0	10	0	0	0	8	-	-	-	-
c.	0	445	0	0	10	0	0	8	-	-	-	-	-	-
d.	170	5	220	0	30	38	-	-	-	-	-	-	-	-
e.	315	4	0	1	6	3	1	4	0	23	1	0	11	1
f.	234	217	12	-	-	-	-	-	-	-	-	-	-	-
g.	-	463	-	-	-	-	-	-	-	-	-	-	-	-
h.	-	463	-	-	-	-	-	-	-	-	-	-	-	-
i.	-	463	-	-	-	-	-	-	-	-	-	-	-	-
j.	-	463	-	-	-	-	-	-	-	-	-	-	-	-
k.	3	1	0	0	0	138	0	32	7	0	0	0	86	1
l.	9	33	11	0	343	0	32	2	3	0	16	2	1	0

Coded Item*	15	16	17	18	19	20	21	22	23	24	25	26	27
a.	-	-	-	-	-	-	-	-	-	-	-	-	-
b.	-	-	-	-	-	-	-	-	-	-	-	-	-
c.	-	-	-	-	-	-	-	-	-	-	-	-	-
d.	-	-	-	-	-	-	-	-	-	-	-	-	-
e.	0	84	9	-	-	-	-	-	-	-	-	-	-
f.	-	-	-	-	-	-	-	-	-	-	-	-	-
g.	-	-	-	-	-	-	-	-	-	-	-	-	-
h.	-	-	-	-	-	-	-	-	-	-	-	-	-
i.	-	-	-	-	-	-	-	-	-	-	-	-	-
j.	-	-	-	-	-	-	-	-	-	-	-	-	-
k.	71	23	51	3	10	3	1	7	4	1	5	14	2
l.	9	2	-	-	-	-	-	-	-	-	-	-	-

*Refer to code in appendix.

2 per cent for a total of 57 per cent of all failures. As indicated by the underlined items, 34 per cent of all failures were involved in fatigue of primary structure.

2. Separation of metal to metal bonded joints accounted for 11 per cent of the total failures; 80 per cent of these occurred on rotor blades.

3. Corrosion accounted for 7 per cent of all the failures -- 62 per cent of these being magnesium stringers and skin, and 22 per cent being steel tubular trusses. All of these occurred on fuselage structures.

4. In addition to corrosion, 11 per cent of the total failures involved surface damage. Of this 11 per cent, dents in rotor blades accounted for 26 per cent; rotor blade erosion accounted for 20 per cent; and landing skid shoe abrasion during pilot training accounted for 50 per cent.

5. Rotors developing vibrations during service accounted for 8 per cent of the total failures. Sixty-two per cent of these failures involved blades that became unbalanced during service, while 37 per cent became untrackable during service. Of the blades that became unbalanced, 61 per cent were reported to contain water. These blades containing water utilized perforated honeycomb core in their construction.

LITERATURE SEARCH (DDC) RESULTS

A search of the recent literature listed by the Defense Documentation Center (DDC) yielded the information in each problem area as discussed below:

1. Despite the many current research programs on metal fatigue, no one program or combination of programs points to a direct solution. Although it would be desirable to have an accurate theory to explain the exact nature of the fatigue mechanism, structural failures could be reduced significantly through the development of structural materials with improved damping characteristics. Since sandwich materials offer great potential from this standpoint, work in this area should be continued.

2. The information in the failure reports was insufficient to isolate the exact cause of the majority of the metal bonding separations found on rotor blades -- more background information is needed since many factors, such as usage, design, fabrication, adhesive, etc., may be involved. Bonding separation is considered a vital problem and further study is recommended.

3. The most urgent and important case of material surface damage noted in the survey was rotor blade dents and leading edge erosion. Recent work in this area has been done by the Boeing Company (TCREC Technical Report 62-111, Helicopter Rotor Blade Erosion Protective Materials, Phase I), and should be continued.

4. No research programs were found which would lead to a clear-cut solution of the corrosion problem. The approach that offers the greatest promise is probably the development of construction materials which are not susceptible to corrosion, such as fiberglass reinforced plastics.

5. A significant failure in the realm of rotor blade construction was discovered during the course of the survey. Blades that became unbalanced while in service were reported to contain water. Liaison with the manufacturer revealed that perforated honeycomb core was used in the construction of these blades. These facts indicate that either water which had leaked into the blade or internal condensation had passed through the perforations and collected to produce the unbalanced condition. Thus, it is recommended that when honeycomb core material is employed in rotor blade construction, the sealed or nonperforated type be favored.

APPENDIX

REPORT ANALYSIS SYSTEM
AIRCRAFT STRUCTURAL FAILURES

INTRODUCTION

Usually, the degree to which a coding system is subject to the interpretation of the operator is inversely proportional to the complexity of the code. To hold the developmental time and cost to a minimum, and to facilitate rapid use of the code to aircraft structural failures caused by fatigue, corrosion, and abrasion, a relatively simple one was devised. Hence, there are, of necessity, areas open for interpretation. These instructions were written to ensure uniform use of the code.

In the use of the code, care must be exercised to focus attention on the failure itself and not its results or some side effect. The terms "none" and "unknown" found throughout the code should be used with care: "none" when the report so states or implies, and "unknown" when an answer is suspicioned to exist under the item in question. When an item is not deemed to be significant to the failure, it should be coded "not applicable". This applies to all items.

To account for all failures, University of Oklahoma Research Institute (OURI) numbers should be assigned to account for the additional failures of like items totaled under item 7 (quantity defective) in block 32 of the basic EIR. These data sheets should be fastened to the prime data sheet with a note to the key puncher to punch them so that they are identical to the prime sheet except where indicated. (Example: OURI number, aircraft serial number, aircraft hours, etc.).

Notes should be made on the data sheet in that some information does not lend itself to tabular recording. A word picture of the failure will permit the statistical results to be qualified by pointing out the limitations which affect them, and thus will add insight to and increase confidence in the survey.

The following special notes that pertain to the specified parts of the code will further serve to aid in its use:

2. Aircraft History

   b. How discovered

      The item most significant to the failure should be used.

c. Symptom of failure

This item pertains to the operational aspect of the machine rather than to the maintenance or to any other aspect.

d. Significant occurrence prior to failure, and

e. Occurrence at time of failure

These items are intended to bring out any (operational or maintenance) occurrence that could have brought about or had significant influence on the failure. This is directed toward a one-time occurrence.

f. Mission prior to failure, and

g. Mission at failure

These items are to define the setting of the failure. They serve to isolate the type of operation (both flight and maintenance) under which failure occurs.

h. Mission environment prior to failure, and

i. Mission environment at failure

These items are included to describe the atmosphere, when significant, in which the aircraft was operating when the failure occurred.

j. Aircraft weight

This item serves to define further the type of operation under which failure occurs.

k. Alteration status in vicinity of failure

This item is included to point out any modification in the vicinity of the failure that could have influenced the failure. Routine maintenance, unless significant, should not be included.

l. Hours of operation

Hours since new or overhaul, whichever is significant.

3. Location of Failed Part

b. Position of failed part

This item will serve to identify the position of the failure on the major component or to complete the identification of the major component and then to locate the position of the failure on this component, whichever is pertinent.

c. Function of failed part

This item was included to differentiate between the failures occurring in the airframe (the framework carrying the major loads), to include rotor blades; the elements of the airframe such as fairings that carry no major loads; and the parts and components on the airframe that are essential to the integrity of the airframe, such as the helicopter transmissions or the main thrust bearing in the transmission.

d. Name of failed part

The names listed under this item are as inclusive as possible, to permit categorizing of failures without being hamstrung with individual details.

e. Condition significant in immediate vicinity

This item was included to give insight to the mechanism of the failure. Any condition that could have brought about, contributed to, or been significant to the failure should be noted.

4. Material and Failure Description

a. Composition of failed part

This item was included to aid in establishing what structural material has experienced the most failures. The possibility

exists of the significance of this item's being weakened by the term "unknown". Every effort should be made to obtain the necessary technical data on each aircraft. Should a component be composed of several materials fastened together, only the composition of the failed section should be used.

b. If composite, core composition; and

c. If composite, skin composition

When these items are employed following the use of laminate in a., they will be understood to describe the composition of the layers in the laminate, the term "skin" being used for outside or exposed layer. They were originally included to describe honeycomb core sandwich materials.

e. Method of loading

Many times the method of loading can be determined by the layout of the failed structure or part.

f. Metallic fracture

This item is included to assist in fatigue cases, but it also covers static breaks.

g. Metallic fracture surface, peripheral;

h. Metallic fracture surface, core;

i. Metallic fracture appearance, peripheral; and

j. Metallic fracture appearance, core

These items are to describe the physical features of a catastrophic rupture, a complete separation. Their greatest benefit would be to substantiate a fatigue failure. For a skin crack these would most logically be coded "not applicable" while for a crack in a thicker element "unknown" would be an acceptable code.

k. Mode of failure

In this item, mode of failure means method of failure, and hence, is one of the most valuable of all the facets to the description of the failure. Not only does this item permit description of a catastrophic type failure, but also of a failure where degeneration of performance is involved.

l. Condition of the failed part

This item is included to help pinpoint the significant local environment or conditions that existed at the time of the failure.

CODE

This code was developed for use on punched cards as illustrated on the Failure Report Analysis Sheet which is included as the last item in this appendix. The code is quite extensive and can be used for failure analyses far beyond the scope of the failure incidence covered in this report.

1. Aircraft Identification

   a. OURI log number: (5 columns)

   b. Date of failure--month, day, year: (6 columns)

   c. Aircraft serial number: (6 columns)

   d. Aircraft category: (2 columns)

      01 Fixed wing
      02 Helicopter
      03 Tilt wing VTOL
      04 Fan in wing VTOL
      05 Vectored jet VTOL
      06 Tilt rotor VTOL
      07 Unload rotor convertaplane

   e. Aircraft designation:

      Special configuration: (2 columns)

      01 None
      02 Unknown
      03 Attack
      04 Special electronic installation
      05 Trainer
      06 Not significant

      Aircraft: (2 columns)

      01 UH-1
      02 OH-4
      03 OH-5
      04 OH-6
      05 OH-13
      06 UH-19

07	CH-21	17	U-8
08	OH-23	18	U-9
09	CH-34	19	OV-1
10	CH-37	20	CV-2
11	NH-41	21	XV-3
12	CH-46	22	XV-4
13	CH-47	23	XV-5
14	O-1	24	XV-6
15	U-1	25	CV-7
16	U-6		

Aircraft Model: (2 columns)

01	No letter	07	L
02	A	08	S
03	B	09	D
04	C	10	F
05	E	11	G
06	K	12	H

f. Aircraft Operator: (2 columns)

01 Active Army
02 Army (N.G. & Reserve)
03 Navy
04 Naval Reserve
05 Air Force
06 Air National Guard
07 Coast Guard

2. Aircraft History

a. Source of this data: (2 columns)

01 Failure report (EIR, etc.)
02 Accident report
03 Forced landing message
04 Engineering changes
05 Analysis report
06 Commercial operator
07 Failure report + analysis report

b. How discovered: (2 columns)

01 Unknown
02 Ground operational check
03 Operational deficiency in flight
04 During accident investigation
05 Caused accident
06 During maintenance
07 In-flight observation
08 Operational deficiency in flight plus caused accident

c. Symptom of failure: (2 columns)

01 Unknown
02 None
03 Vibration
04 Loss of operational efficiency
05 Loss of control
06 Vibration and loss of control
07 Noise during operation
08 Noise during run-down or securing
09 Not applicable

d. Significant occurrence prior to failure: (2 columns)

01 Unknown
02 None
03 High G maneuver
04 Hard landing or landing on unsuitable surface
05 Mishandling while on ground
06 Flight in turbulence
07 Overspeed of rotating component
08 Exposure to high humidity or rain
09 Failure to remove drilling or machining chips
10 Overtorqued
11 Excessive component vibration developed

e. Occurrence at time of failure: (2 columns)

01 Unknown
02 None
03 High G maneuver

04 Hard landing or landing on unsuitable surface
05 Mishandling while on ground
06 Flight in turbulence
07 Overspeed of rotating component
08 Exposure to high humidity or rain
09 Installing or removing part
10 Overtorqued
11 Excessive component vibration developed

f. Mission prior to failure: (2 columns)

01 Unknown
02 Acrobatic flight
03 Normal utility or cargo flight including landing or take-off
04 Nap-of-the-earth flight
05 Short strip or small area landing or take-off
06 Training, not covered by other missions listed
07 Instrument flight
08 Not applicable
09 Combat operations

g. Mission at failure: (2 columns)

01 Unknown
02 Acrobatic flight
03 Normal utility or cargo flight including landing or take-off
04 Nap-of-the-earth flight
05 Short strip or small area landing or take-off
06 Training, not covered by other missions listed
07 Instrument flight
08 Not applicable
09 Compliance with maintenance order
10 Combat operations

h. Mission environment prior to failure: (2 columns)

01 Unknown
02 Arctic
03 Arid
04 Sandy/dusty
05 Tropic

06 Coastal (rain and high humidity with salt atmosphere)
07 Moderate-average, summer
08 Not applicable
09 Rain and high humidity
10 Moderate-average, winter
11 Icing
12 Gusty winds

i. Mission environment at failure: (2 columns)

01 Unknown
02 Arctic
03 Arid
04 Sandy/dusty
05 Tropic
06 Coastal (rain and high humidity with salt atmosphere)
07 Moderate-average, summer
08 Not applicable
09 Rain and high humidity
10 Moderate-average, winter
11 Icing
12 Gusty winds

j. Aircraft weight: (1 column)

1 Unknown
2 Near normal gross weight
3 Near empty
4 Above normal gross weight
5 Intermediate weight
6 Not applicable

k. Alteration status in vicinity of failure: (2 columns)

01 Unknown
02 None
03 Non-compliance with safety directive
04 Local repair in vicinity recently
05 Local repair of failed part recently
06 Indication of need for repair or balance

l. Hours of operation:

Hours on airframe: (4 columns)
Hours on power plant: (4 columns)
Hours on failed part: (4 columns)

Note: Use the following key in the first column of each of the above.

1 Unknown
2 Not applicable
3 0 - 1,000 hours
4 1,000 - 2,000 hours
5 2,000 - 3,000 hours
6 3,000 - 4,000 hours
7 5,000 - 6,000 hours

m. Last overhaul station of failed part: (2 columns)

01 Unknown
02 Has not been overhauled - new
03 U.S. Army Transportation Aeronautical Depot Maintenance Center (ARADMAC)
04 Bell Helicopter Company
05 Not applicable
06 Parsons
07 Sikorsky
08 Avalando
09 Societe Anonyme Belge Construction (SABCA)
10 Sud-Aviation

3. Location of Failed Part

a. Major component: (2 columns)

01 Fuselage
02 Wing
03 Control system
04 Vertical tail surface
05 Horizontal tail surface
06 Undercarriage
07 Rotor blade or blades
08 Rotor head
09 Transmission
10 Power plant
11 Tail rotor pylon
12 Wing nacelle
13 Tail boom (on helicopters)
14 Crew restraint system
15 Passenger restraint system

b. Position of failed part: (2 columns)

01	Not applicable	07	Control system
02	Front or root	08	Louver
03	Intermediate or main	09	Seat structure
04	Aft or tip or tail	10	Occupant tie-down
05	Control surface	11	Main at tip
06	Flap	12	Counter weight

c. Function of failed part: (1 column)

1 Structural, vital (airframe carrying major loads)
2 Nonstructural, vital (airframe components and fixtures)
3 Structural, not vital (airframe and appendages not carrying major loads)

d. Name of failed part: (2 columns)

01	Skin	19	Beam or spar
02	Fitting	20	Shoe
03	Strut	21	Blade grip
04	Brace	22	Leading edge
05	Bearing	23	Mounting cap
06	Beam flange or stringer	24	Bulkhead mount or gusset
07	Beam web	25	Ring or frame gusset
08	Link	26	Rib
09	Fastener, hardware	27	Stiffner or doubler
10	Cowling or cover	28	Bulkhead
11	Shaft	29	Ring or frame
12	Mount structure	30	Ring or frame with bulkhead
13	Tubing	31	Door or window
14	Belt	32	Pedestal
15	Yoke	33	Accessory mount structure
16	Same as major component	34	Instrument panel mount structure
17	Horn	35	Strut cap
18	Trim tab	36	Spring strut (leafed)

e. Condition significant in immediate vicinity: (2 columns)

01 Near notch or cut out
02 In curvature or bend

03 Near joint, welded
04 Near joint, riveted or bolted
05 Near notch or cut out and in curvature
06 Clear
07 Exposure to slipstream
08 Exposure to localized heat source
09 Exposure to high noise level
10 Near manufacturing flaw such as a scratch
11 Misfitted or misaligned with mating parts during installation
12 Near an unintentional injury to part
13 Insufficient lubrication
14 Near abrupt change in section--threads, flange, etc.
15 Insufficient bonding material
16 Insufficient bonding material and exposed to slipstream
17 None
18 Unknown
19 Exposure to landing surface
20 Near power plant
21 Sealing material deteriorated or separated
22 New part installed in system
23 Near stored part
24 Near joint, riveted or bolted, in curvature

4. Material and Failure Description

a. Composition of failed part: (2 columns)

01 Metal, steel
02 Metal, aluminum
03 Metal, magnesium
04 Metal
05 Metal, unknown composition
06 Plastic, solid
07 Composite--honeycomb core
08 Laminate
09 Not applicable
10 Metal and rubber
11 Wood

b. If composite, core composition: (2 columns)

01 Unknown
02 Not applicable
03 Paper
04 Fiberglass
05 Metal, steel
06 Metal, aluminum
07 Metal, magnesium
08 Metal
09 Metal
10 Rubber

c. If composite, skin composition: (2 columns)

01 Unknown
02 Not applicable
03 Fiberglass
04 Metal, steel
05 Metal, aluminum
06 Metal, magnesium
07 Metal
08 Metal, unknown composition

d. Type of load: (2 columns)

01 Unknown
02 Static
03 Repeated or cyclic, resonance unknown
04 Resonant vibration
05 Surface impact and abrasion
06 Not applicable

e. Method of loading: (2 columns)

01 Unknown
02 Pure shear
03 Tension
04 Compression
05 Torsion
06 Tension-compression
07 Bending
08 Bending and torsion
09 Tension and torsion
10 Bending-torsion-tension
11 Tension-bending
12 Thrust and radial
13 Bending and shear
14 Tension and shear
15 Tension-compression-shear
16 Not applicable
17 Compression and shear

f. Metal fracture: (2 columns)

01 Not applicable
02 Cracked
03 Completely separated

g. Metallic fracture surface, peripheral: (2 columns)

01 Unknown
02 Not applicable
03 Stop marked
04 Peaked and/or with 45-degree surfaces

05 Beach marked
06 Granular, coarse
07 Granular, fine

h. Metallic fracture surface, core: (2 columns)

01 Unknown
02 Not applicable
03 Peaked and/or with 45-degree surfaces
04 Beach marked
05 Granular, coarse
06 Granular, fine

i. Metallic fracture appearance, peripheral: (2 columns)

01 Unknown
02 Not applicable
03 Shiny
04 Dull and velvety

j. Metallic fracture appearance, core: (2 columns)

01 Unknown
02 Not applicable
03 Shiny
04 Dull
05 Velvety

k. Mode of failure: (2 columns)

01 Shear
02 Tension
03 Compression
04 Fatigue followed by shear
05 Fatigue followed by tension or compression
06 Evidence of fatigue but indeterminate
07 Bending
08 Column or panel buckling
09 Material cracked and separated from internal stresses
10 Core crushing

11 Dimpling of face
12 Shear crimping
13 Skin or surface crack
14 Large deflection occurred
15 Surface of material damaged
16 Became unbalanced
17 Bonding separation
18 Sealing incomplete
19 Fastener came loose
20 Insufficient clearance between elements
21 Support collapsed
22 Shape of surface altered
23 Type of material failure unknown
24 Excessive clearance between elements
25 Holes in materials
26 Blade would not remain in track in forward flight
27 Fastener hole enlarged

I. Condition of failed part: (2 columns)

01 Unknown
02 Corroded
03 Eroded
04 Like new
05 Normal wear state
06 Discolored as from heat
07 Excessive wear--abrasion
08 Bent
09 Imperfect details of design
10 Galled and chipped
11 Absorbed water
12 Scratched or gouged
13 Imperfect details in manufacture
14 Threads stripped
15 Absorbed water and frozen
16 Cracked and deteriorated (for nonmetals)

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Data Sheet
Engineering Survey
Aircraft Structural Failures

Recorded ____________
Punched ____________
Verified ____________

AIRCRAFT IDENTIFICATION

OURI LOG NUMBER							DATE OF FAILURE								AIRCRAFT SERIAL NUMBER								AIRCRAFT CATEGORY				AIRCRAFT DESIGNATION							AIRCRAFT OPERATOR		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37

AIRCRAFT HISTORY

SOURCE			DISCOVERED			SYMPTOM			BEFORE FAILURE			AT FAILURE			MISSION BEFORE			MISSION AT			ENVIRONS PRIOR			ENVIRONS AT			WEIGHT		ALTERATION			LAST OVERHAUL		
38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72

OURI LOG NUMBER							HOURS ON AIRFRAME					HOURS POWER PLANT					HOURS ON FAILED PART					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

LOCATION OF FAILED PART

COMPONENT			POSITION			FUNCTION		NAME			VICINITY	
24	25	26	27	28	29	30	31	32	33	34	35	36

1. Shaded blocks to be left blank.
2. Entries between shaded areas must be right justified.
3. Unfilled blocks to be zeroed.

MATERIAL AND FAILURE DESCRIPTION

COMPOSITION			COMPOSITE, CORE			COMPOSITE, SKIN			TYPE LOAD			LOADING			TYPE FRACTURE			SURFACE, PERIPHERY			SURFACE, CORE			APPEARANCE, SURFACE			APPEARANCE, CORE			FAILURE MODE			CONDITION		
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72

FAILURE REPORT ANALYSIS SHEET

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